DOI https://doi.org/10.30525/978-9934-26-570-9-27

INNOVATIONS IN THE USE OF GRAIN RAW MATERIALS IN FOOD TECHNOLOGY

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INTRODUCTION

Cultivation of ancient cereal varieties allows today to preserve valuable genetic material adapted to local climatic and soil conditions. Due to consumers' interest in growing ancient cereal varieties, such niche crops are ideal for ecological and organic production, as they are less demanding. They are more resistant to abiotic stresses, including droughts, which are becoming more frequent. The area of their cultivation is becoming larger than the total area of grain crops. These species make it possible to preserve biodiversity in agriculture, but the spread of their production requires greater availability of seed material. Breeding varieties have lost their natural adaptive properties in favor of improved quantitative and qualitative characteristics. Currently, the most common among ancient wheat varieties are: spelt, einkorn, less often emmer (or emmer, spelt, bolba, emmer) and round grain. In spelt, einkorn and emmer, the grain remains in the chaff after threshing. All three species are found in both spring and winter forms. But winter wheat is sown more often, in 2020-2022 there were: 6 varieties of spelt and 2 varieties of emmer and emmer. Emmer wheat is one of the oldest. It is known that it was grown as early as 10,000 BC.

Spelt in EU countries, in particular in Poland, is the most common cultivated ancient species. It adapts well to adverse weather conditions, reaches a height of up to 150 cm and has strong scales that protect the grain from infection. Emmer is grown less often due to its low yield. Its varieties are mostly spiny. It is more widespread in Germany and Italy, where flour from emmer is used for bread and pasta. Einkorn wheat is a difficult cereal crop to grow, with thin stems and short spikelets, and smaller grains than common wheat. Ancient types of cereals thrive well on poorer soils, are more resistant to weather anomalies. They are less susceptible to pests and pathogens, and do not require intensive protection. Since they have tall spikelets with strong straw, the application of mineral fertilizers must be balanced so as not to cause too intensive plant growth. The best predecessor is legumes. The recommended seeding rate is relatively high, which allows plants to compete more with weeds. Winter spelt should be sown at a rate of about 300 kg/ha, and spring wheat − from 220 to 250 kg/ha. Spring wheat – 200 … 230 kg/ha, winter wheat − 250 kg/ha. Both types of einkorn wheat are sown at a rate of 200 kg/ha. They are more difficult to harvest than common wheat because the chaff sticks tightly to the grain, requiring additional cleaning.

Table 1

Domestication of staple foods in the world

Region Name	Plant name	Date
Southwest Asia	wheat, peas, olives	8500 г. BC
China	rice, millet	to 7500 BC
New Guinea	sugarcane, banana	7000 г. BC
Indus Valley	sesame, eggplant	7000 г. BC
Egypt	sycamore, chufa	6000 г. BC
Sahel	sorghum, african rice	to 5000 г. BC
Mesoamerica	corn, beans, squash	to 3500 г. BC
Andes and Amazon	potatoes and cassava	to 3500 г. BC
West Africa	yams, oil palm	to 3000 г. BC
Ethiopia	coffee, teff	3000 г. BC
Western Europe	poppy, oats	3000 г. BC
Eastern United States	sunflower and quinoa	2500 BC

It is believed that food production began to develop actively after the arrival of cultivated plants from Southwest Asia between 6000 and 3500 BC. The distribution area of wild poppy is limited to the coastal areas of the Western Mediterranean. Another region where local domestication occurred is the Indus Valley and South Asia, agricultural communities in 7000 BC used wheat, barley, then in Egypt the sycamore and the local vegetable − chufu appear.

1. Ancient Grains, a Brief Overview

Ancient grains are generally less processed than modern grains such as corn and wheat. Because of this, ancient grains contain more vitamins, minerals, and fiber. Including ancient grains in your diet may provide health benefits. Ancient grains are a group of grains and pseudocereals (seeds eaten as grains) that have remained largely unchanged for thousands of years. They are a staple food in many parts of the world, such as China, India, Africa, and the Middle East. Today, ancient grains are becoming increasingly popular in Western countries. This is because they are generally less processed and contain more vitamins, minerals, and fiber than more common grains such as corn, rice, and modern wheat. Additionally, studies have linked ancient grain consumption to health benefits, such as a reduced risk of heart disease, better blood sugar control, and improved digestion. Here are 12 healthy ancient grains[1 2]:

Amaranth is a nutritious, gluten-free grain that has been cultivated for over 8,000 years. With its impressive nutrient profile, amaranth has been linked to cardiovascular disease and improve blood sugar control. For example, a study in people with type 2 diabetes found that substituting millet for rice in their meals reduced blood sugar levels after eating by 27%. Millet is versatile and gluten-free. It can be enjoyed as a hot breakfast cereal or in place of other grains such as rice, couscous, and quinoa. Khorasan wheat, also known as Kamut, is a grain high in fiber and nutrients that has been linked to health benefits. Kamut may be particularly helpful for lowering blood sugar levels and heart disease risk factors such as LDL (bad) cholesterol. A 4-week human study found that a Kamut-based diet suppressed hormones that promote inflammation and reduced total cholesterol by 4%, LDL (bad) cholesterol by 8%, and blood sugar by 4%, compared to a semi-whole grain diet. This grain contains gluten, making it unsuitable for people with celiac disease, non-celiac gluten sensitivity, or wheat allergies. Kamut has a chewy, nutty texture with grains that are two to three times larger than wheat grains. It’s a great addition to soups, stews, casseroles, and summer salads.

Sorghum is the world’s most consumed grain and a great source of nutrients. Not only is sorghum high in nutrients, it’s also a good source of powerful polyphenolic plant compounds, including anthocyanins and phenolic acids, which act as antioxidants in the body. Antioxidants neutralize potentially harmful molecules called free radicals, which can cause cell damage and increase your risk of disease when they build up in your body. Unlike many other grains, sorghum is naturally gluten-free and can be easily ground into gluten-free baking flour. Its mild flavor makes it very versatile.

Teff is the world’s smallest grain, about 0.7–1% the size of a wheat grain. Teff grains are tiny, but they’re packed with important nutrients like iron and magnesium. They’re also one of the few grains that contain vitamin C, a nutrient vital to immunity and bone health. Conditions like iron-deficiency anemia are relatively rare in Ethiopia, perhaps due to the country’s high consumption of teff grains. For example, a study in pregnant Ethiopian women found that eating teff daily was associated with a significantly lower risk of anemia than eating teff less often. Teff is also gluten-free and can be used in gluten-free porridges, soups, stews, and baked goods. It is available online and in some stores.

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[1] Петриченко В. Ф., Лихочвор В. В. Рослинництво: нові технології вирощування польових культур. Львів: Агорокнига. 2022. 806 с.

[2] Лихочвор В. В., Петриченко В. Ф., Іващук П. Ф. Зерновиробництво. Львів: Агрокнига. 2008. 624 с.

A staple of Middle Eastern cuisine, freekeh is made from green durum wheat and contains a variety of nutrients and powerful carotenoid compounds. Freekeh, in particular, is a good source of the carotenoids lutein and zeaxanthin. Higher intake of these compounds has been linked to a lower risk of degenerative eye diseases such as cataracts and age-related macular degeneration (AMD). Because freekeh contains gluten, people with celiac disease and other gluten-related conditions should avoid it. Freekeh has an earthy, nutty flavor with a chewy texture similar to brown rice. As an all-purpose grain, it's a great addition to soups, stews, casseroles, and summer salads. If you're having trouble finding it in your local grocery store, look online.

Farro is an ancient wheat-based grain that's becoming increasingly popular. In addition to its essential grain nutrients, farro is high in antioxidants like polyphenols, carotenoids, and phytosterols, which may reduce your risk of several chronic diseases, such as heart disease and some cancers. Farro is also particularly high in protein and fiber, which can help you maintain a healthy weight by curbing your appetite and keeping you full after meals. This gluten-containing grain is easy to incorporate into your diet and can be eaten just like other grains. It can be added to salads and soups.

Barley is highly nutritious and one of the most common ancient grains in the American diet. It is high in beta-glucans, a type of soluble fiber that dissolves in water and forms a gel-like substance in the gut. Beta-glucans have also been linked to heart health. For example, a review of studies involving up to a thousand people reported that diets high in beta-glucans from barley significantly reduced LDL (bad) cholesterol and increased HDL (good) cholesterol, compared to control diets. Barley is affordable, widely available, and easy to eat. However, it is gluten-free. It can be eaten as a side dish in place of other grains or added to soups, fillings, and salads. Quinoa is a popular, gluten-free ancient grain that has impressive health benefits. Quinoa contains powerful antioxidants, such as quercetin and kaempferol, which have been shown in animal studies to have anti-inflammatory and anti-cancer properties. Moreover, this grain is an excellent source of plant protein.

Quinoa, which is the most filling element, and adding more protein-rich foods to your diet can help regulate hunger and promote weight loss. Due to its popularity, quinoa is widely available in supermarkets and health food stores. It has a mild flavor and is easy to add to breakfast, lunch, and dinner.

Bulgur, also called cracked wheat, is a staple in Middle Eastern cuisine. Bulgur is often made from cracked durum wheat and is often added to salads such as tabbouleh or used in place of rice in dishes such as pilaf. Its high fiber content may promote heart health, good digestion, blood sugar control, and weight loss. While bulgur is beneficial for most people, it is a wheat product, so people who are gluten or wheat intolerant should avoid it.

Rye is a popular ancient grain that belongs to the wheat family. However, compared to wheat, rye contains fewer carbohydrates and more vitamins and minerals. Due to its high fiber content, rye and rye-based products may be more effective in relieving constipation than wheat-based products and laxatives. Additionally, higher intakes of fiber-rich whole grains like rye have been linked to a reduced risk of certain cancers, including breast and colorectal cancer. While rye is very healthy, it is worth noting that it is gluten-free.

Fonio is a type of millet that is widely consumed in West African countries. The two most common varieties are white fonio (Digitaria exilis) and black fonio (Digitaria iburu). Fonio also boasts ample amounts of magnesium, copper, and zinc. It may contain resistant starch, which passes through your digestive tract undigested and feeds healthy gut bacteria. These bacteria break down resistant starch into short-chain fatty acids (SCFAs), which, among other benefits, may help lower blood sugar and inflammation. Fonio is not widely available in the United States, but it can be purchased online. It can be ground to make a delicious gluten-free flour for baking, or cooked for a fluffy, couscous-like texture.

Ancient grains have gained popularity in recent years because they tend to be less processed and contain more vitamins, minerals, and fiber than conventional grains. Diets high in ancient grains have been linked to health benefits, such as improved blood sugar levels and reduced inflammation, as well as heart disease and cancer risk.

2. Use of Cereal Carbohydrates in the Food Industry

Recently, among innovative products in the food industry, health or functional products have become popular. The segment of the functional products industry is growing rapidly due to consumer demand for products that are beneficial to health and have a positive effect on human well-being. They are produced by enriching them with physiologically functional ingredients – vitamins, minerals, dietary fibers, probiotics, some amino acids, ω-fatty acids, phospholipids, extracts of various herbs and plants. Consumers prefer natural products and the use of fewer synthetic components in their composition. In view of this, manufacturers should use additives that are alternative to traditional components, ensuring the production of a product of proper quality, in particular, food additives of polysaccharide nature. Dietary fibers are considered functional ingredients, since they affect physiological and biochemical processes in the human body, which leads to improved health and a reduced risk of many diseases[3] [4]. In particular, dietary fibers are sorbents, bind and remove toxic substances, radionuclides, heavy metals from the body, have the properties of prebiotics, which provide stimulation of growth and/or increase in biological activity of beneficial microflora, contribute to reducing the level of cholesterol and/or glucose in the blood. At the same time, they perform technological functions in food products, because they have the appropriate properties, in particular, they have the ability to thicken, gel, stabilize emulsions and foams, etc. Food additives of polysaccharide nature, due to their special technological properties, even at very low concentrations, significantly affect the organoleptic and physicochemical indicators of food products, which ensures the quality of products dictated by the modern market. The world production of food additives of polysaccharide nature is developing intensively, the areas of their application are expanding. This is, first of all, the meat processing industry, the production of beverages, and fermented milk products. The use of such additives has increased in the production of bread, bakery, flour and confectionery products, desserts, ice cream, and dairy products. In recent years, active work has been carried out to develop technologies for new food additives of polysaccharide nature – dietary fibers, the use of which allows not only to improve the organoleptic quality indicators of products and stabilize their quality during storage, but also to give products functional properties. These can be both individual ingredients and complex mixtures based on them. Physiologically functional ingredients differ significantly in their organoleptic and physicochemical properties, such as solubility, charge, polarity, reactivity, so each drink must be carefully formulated taking into account the specific components that make up its composition. The rapid growth of the market for functional food products, and at the same time the growth in popularity and expansion of the range of food additives of polysaccharide nature, is accompanied by the emergence of difficulties associated with the necessary selection of such additives to solve specific technological tasks. The purpose of this review is to summarize the data of modern scientific literature on technological aspects of the use of dietary fibers in the production of soft drinks. To achieve this goal, the following tasks need to be solved: to analyze the range of food additives belonging to dietary fibers; to investigate the main physicochemical, functional and technological properties of dietary fibers; to study the practical experience of their application; to propose objects of application and dosage volumes of these additives in the production of soft drinks to solve specific technological

[3] Ластухін Ю. О. Харчові добавки. Е-коди. Будова. Одержання. Властивості. Львів : Центр Європи, 2009. 836 с.

[4] Полумбрик М. О. Вуглеводи в харчових продуктах і здоров’я людини. Київ : Академперіодика, 2011. 487 с.

problems. The materials of the study were modern scientific publications of domestic and foreign scientists concerning the structure and properties of soluble dietary fibers obtained from various sources and their use for the production of soft drinks, in particular functional ones. Theoretical research methods were used: the method of analysis and selection of information sources, generalization and systematization of data.

3. Classification of dietary fibers

Dietary fibers are understood as polymers of carbohydrates with a degree of polymerization of at least three, which are not digested and not absorbed in the gastrointestinal tract of the human body. Dietary fibers can be naturally contained in food or added to food products as food additives, isolated from food raw materials by physical, enzymatic or chemical methods or obtained by synthesis. Non-starch polysaccharides predominate among dietary fibers and, depending on their solubility in water, they are divided into: soluble and insoluble. Soluble dietary fibers include pectins, inulin, β-glucan, gums, while insoluble ones include cellulose, hemicelluloses, resistant starches, arabinoxylans. Food products contain dietary fibers of both groups, soluble and insoluble, in different proportions. Polysaccharide molecules that belong to dietary fibers differ in the composition of the monosaccharide residues from which they are built, the degree of polymerization, and molecular weight[5] [6]. They can be both homogeneous and heterogeneous in molecular composition, have different functional groups (methoxyl, hydroxyl, acetyl, amide, carboxyl), have a linear or branched chain structure, and be in different conformations. Chemical modification of insoluble polysaccharide molecules leads to changes in their properties and functions in food systems. Due to chemical modification of insoluble cellulose (esterification with mineral acids or anhydrides of organic acids), its soluble derivatives are obtained. Pectin is a natural structural component present in the cell walls of plant cells, as well as in their intracellular layers. Pectin is a structural complex formed by homogalacturonan, rhamnogalacturonan I, rhamnogalacturonan II and xylogalacturonan[7]. Despite their general characteristics, pectins can have a variety of structures, which vary depending on the source and method of their extraction. In addition, pectins are subject to physical, chemical and/or enzymatic changes. In the pectin molecule,

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[5] Aires da Silva D., Cristine Melo Aires G., da Silva Pena R. Gums-Characteristics and Applications in the Food Industry. IntechOpen. 2021. DOI: 10.5772/intechopen.95078

[6] Бажай-Жежерун С., Береза-Кіндзерська Л. Природні харчові сорбенти зерна. Вчені записки Таврійського національного університету імені В.І. Вернадського. 2022. 33(72). № 6. С. 233–237.

[7] Freitas C. M. P., Coimbra J. S. R., Souza V. G. L., Sousa R. C. S. Structure and Applications of Pectin in Food, Biomedical, and Pharmaceutical Industry: A Review. Coatings. 2021. 11(8), 922.

galacturonic acid residues are esterified with methyl alcohol. According to the degree of esterification, pectins are classified into highly esterified (HM) (>> 50%) and low esterified (LM) (not more than 50%), which have different properties and different industrial applications. Inulin and its enzymatic hydrolysis products consist of fructans of the type GFn and Fm, where G denotes a glucose fragment, F denotes fructose, and n and m denote the number of fructose fragments. Inulin extracted from dahlias with hot water contains 92% fructooligosaccharides, mainly of the GFn type (98%), in which the n value ranges from two to 60 and the average degree of polymerization is 10. The degree of polymerization of almost 10% of fructans ranges from two to five. Inulin obtained from plant raw materials has a low degree of polymerization (less than 200), while inulin of bacterial origin has a high degree of polymerization (more than 10 thousand). Inulin obtained with the help of bacteria has a more branched structure compared to inulin obtained from plants. A large group of dietary fibers are gums. The term "gum" is mostly used to refer to hydrophilic or hydrophobic molecules with high molecular weight that have colloidal properties. Gums are classified into groups according to their origin, properties and chemical structure[8]. Water-soluble gums are obtained: from plant seeds (guar gum, locust bean gum); from plant root tubers (konjac gum); exudates of trees or shrubs (tragacanth, gum arabic); algae extracts (alginates, carrageenans); biochemically using microorganisms (xanthan gum, gellan gum). The structure of dietary fibers is complex, for the most part they are a mixture of a significant number of various carbohydrates, and the technological properties and features of their use in food technologies depend to a large extent on it.

4. Factors affecting the use of dietary fiber

The main physicochemical properties of dietary fiber are solubility, viscosity, gel-forming ability, and ability to stabilize dispersed systems. Dietary fiber belongs to the group of long-chain polymers that form viscous dispersions or gels when dispersed in water. They form a dispersed system that is intermediate between a true solution and a suspension, and exhibit the properties of colloids. Given this, such polymers are called hydrophilic colloids or hydrocolloids. The process of dissolving dietary fiber occurs in two stages – swelling and actual dissolution. The higher the molecular weight of the polymer, the slower the process of swelling and dissolution. Swelling does not always end with dissolution. In this regard, unlimited and limited swelling are distinguished. Unrestricted swelling ends with the dissolution of the hydrocolloid, while with limited swelling the polymer absorbs the solvent and does not dissolve in it, regardless of the duration of the interaction. The

[8] Mudgil D., Barak S., Khatkar B. S. Guar gum: processing, properties and food applications-A Review. Journal of food science and technology. 2014. 51(3), 409–418.

molecular structure of the polysaccharide is a factor that determines its solubility in water. Polysaccharides consist of monomeric units of monosaccharides (glucose, galactose, mannose, xylose, arabinose, etc.), and the monosaccharide units present in the polysaccharide chain undergo structural changes in solution. As a result of reversible intramolecular chemical reactions between the − CHO and −OH groups, they acquire a hemiacetal structure. The hemiacetal can form glycosidic bonds and react with the − OH groups of other monosaccharide units. However, the solubility of a polysaccharide depends more on the type of bonds than on the type of monosaccharide units present in it. For example, cellulose and β-glucan are composed of the same monomer units, but the type of bond between the monomer units is different. In the cellulose molecule, glucose residues are connected by β-(1,4)-glycosidic bonds, while in β-glucan − by both β-(1,4)– and β-(1,3)-glycosidic bonds. Because of this, the polymers exhibit different solubility in water − cellulose is insoluble, while β-glucan is water-soluble. Linear regular (those with one type of intermonosaccharide bond) polysaccharides, such as cellulose, xylan, are not soluble in water. β-Glucans are unable to form an ordered crystalline structure, which determines their solubility. Dietary fibers contain polar functional groups (hydroxyl, sulfate), which can form hydrogen bonds with water molecules and increase the hydrophilicity of molecules (carrageenans). The more polar groups in a molecule, the better it dissolves in water. Solubility increases if there are side chains in polysaccharide molecules, which improves hydration (xanthan gum). Solubility decreases under the influence of factors that contribute to the formation of bonds between polysaccharide chains: the presence of unbranched sections and sections without ionized groups (locust bean gum); the presence of calcium ions or other polyvalent cations that cause the interaction of polysaccharide chains, which prevents dissolution (pectin). Therefore, one of the main conditions for the effective use of dietary fibers in a specific food system is their complete dissolution, which depends on the chemical nature. Dietary fiber macromolecules do not dissolve in water as easily as molecules with a lower molecular weight, and some of them (highly methoxylated pectin, locust bean gum, gellan gum) require high temperatures to dissolve. The solubility of polysaccharides is determined by several of their structural characteristics: the branching of the molecules, the presence of ionized groups, the type of bonds between the monosaccharide units, and the heterogeneity of the structure[9].

Water-soluble polysaccharides mostly form viscous solutions due to the interaction of polar functional groups of hydrocolloids with water molecules with the formation of hydrogen bonds. At the same time, the folded

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[9] Singh A. K., Malviya R., Rao G. S. N. K. Locust Bean Gum: Processing, Properties and Food Applications. Recent Advances in Food Nutrition & Agriculture. 2022. 13(2), 93–102.

polysaccharide macromolecules transition to an unfolded conformation, which significantly increases the viscosity of the system, since the hydrodynamic resistance for molecules of a linear structure is maximum. Physical interactions, such as the intertwining of polysaccharide molecules in aqueous solutions, are the main cause of the viscosity of these solutions. Polysaccharide macromolecules are long threads that are intertwined with each other or twisted into coils. In dilute solutions, they move freely due to the presence of free volume between their molecules, while in concentrated solutions, polysaccharide molecules overlap, interpenetrate and intertwine with each other, which leads to an increase in the viscosity of the solution. In view of this, the concentration of polysaccharides is an important factor affecting the viscosity of their solutions, table 2.

Table 2

Structural features of dietary fibers

Name	**A functional monosaccharide residue**	**Molecular weight, a.o.**
Modified cellulose	β-D-glucose	20 – 500 thousand
Pectin	CH_3, $-CH_2CH_3$, $-CH_2CH_2OH$, $-CH_2CH(OH)CH^3$	25 – 200 thousand
Inulin	α-D-galacturonic acid	5 – 7 thousand
Biochemical gums	β-D-fructose	500 thousand – 50 million
Tree gums	β-D-glucose, β-D-glucuronic acid, α-L-rhamnose	400 – 800 thousand
Algae gums	D-galactose, L-rhamnose, D-galacturonic acid	10 – 600 thousand
Tuber gums	β-D-galactose, β-D-mannuronic, α-L-guluronic acid	200 thousand – 5 million

The viscosity of solutions of dietary fibers largely depends on their molecular weight. In addition, the molecular structure has a significant effect – linear molecules form solutions of higher viscosity and, conversely, the presence of branching in molecules generally negatively affects viscosity − it decreases. Charged polymer molecules have a higher viscosity than non-ionized molecules with the same molecular weight. Water-soluble dietary fibers are the main additive used in food technology to increase the viscosity of solutions. Some hydrocolloids in solution, upon heating or cooling or when cations are added, can form a gel − a structured colloidal highly dispersed system with a liquid dispersion medium that fills the frame of cross-linked polymer chains of the gel former (disperse phase particles).

Water-soluble polysaccharides mostly form viscous solutions due to the interaction of polar functional groups of hydrocolloids with water molecules, forming hydrogen bonds, thus reducing the mobility of water and increasing the overall viscosity of the system. At the same time, the folded polysaccharide macromolecules transition to an unfolded conformation, which significantly increases the viscosity of the system, since the hydrodynamic resistance for molecules of a linear structure is maximum. Physical interactions – the intertwining of polysaccharide molecules in aqueous solutions – are the main reason for the viscosity of solutions. Polysaccharide macromolecules are long threads that intertwine with each other or twist into balls. In dilute solutions, they move freely due to the free volume between the molecules, while in concentrated solutions, polysaccharide molecules overlap, mutually penetrate and intertwine with each other, which leads to an increase in the viscosity of the solution. In view of this, the concentration of polysaccharides is an important factor affecting the viscosity of their solutions. The viscosity of solutions of dietary fibers largely depends on their molecular weight. In addition, the molecular structure has a significant effect – linear molecules form solutions of higher viscosity and, conversely, the presence of branching in molecules generally negatively affects the viscosity − it decreases. Charged polymer molecules have a higher viscosity than non-ionized molecules with the same molecular weight[10] [11].

Gel formation consists in the association of randomly dispersed polymer segments in a dispersion with the formation of a three-dimensional network containing a solvent. At the same time, the junction sites can be formed by two or more polymer chains. The location of the junction sites in the network can be influenced by various parameters: temperature, ions, and the structure of the hydrocolloid. Three main mechanisms have been proposed for the gelation of hydrocolloids: ionotropic, cold, and thermal. Ionotropic gelation consists in the cross-linking of hydrocolloid chains using ions. In cold gelation, hydrocolloids are dissolved in hot water to form a dispersion, which forms a three-dimensional network upon cooling. Agar and gelatin gels are formed using this mechanism. In thermal gelation, the native polysaccharide molecules unfold and their subsequent rearrangement to form a network. In this way, gels are formed, in particular, methylcellulose, hydroxypropylmethylcellulose. At the same time, different dietary fibers capable of forming gels require different conditions for this. Thus, the gelation of highly methoxylated pectins depends on their molecular weight, degree of esterification, sugar concentration in the medium, temperature, pH

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[10] Qin Y., Zhang G., Chen H. The applications of alginate in functional food products. J. Nutr. Food Sci. 2020. 3, 100013.

[11] . Dixit, V., Joseph Kamal, S. W., Chole, P. B., Dayal, D., Chaubey, K. K., Pal, A. K., Xavier, J., Manjunath, B. T., & Bachheti, R. K. Functional Foods: Exploring the Health Benefits of Bioactive Compounds from Plant and Animal Sources. Journal of Food Quality, 2023 (1), 5546753. https://doi.org/10.1155/2023/5546753

of the medium. In contrast, the gelation of low-methoxylated pectins does not depend on pH and dry matter content. The properties of the formed gels significantly depend on the nature of the hydrocolloid. In weak gels, the framework contains a small number of connection sites, such a gel is easily destroyed under the influence of external pressure or with a small increase in temperature. Conversely, in the network of strong (hard) gels, the number of connection sites is large, so they can withstand external pressure and are heat-resistant. The ability to form gels is an important technological property of some dietary fibers. Hydrocolloids have the ability to stabilize dispersions (suspensions, emulsions, foams) formed from two or more phases that are completely or practically immiscible and do not react with each other. One of the phases forms a continuous dispersion medium (liquid, gas, solid), in the volume of which the dispersed phase is distributed in the form of small solid particles, liquid droplets or gas bubbles. The stabilization effect can be achieved due to the adsorption of hydrocolloid molecules at the phase interface and/or an increase in the viscosity of the dispersion medium. The targeted use of different hydrocolloids makes it possible to regulate the course of the technological process and improve the quality of the finished product. The most effective is the simultaneous use of several hydrocolloids in the composition of stabilization mixtures[12] [13] [14]. Therefore, one of the main conditions for the effective use of dietary fibers in certain food industries is their dissolution, which significantly depends on the chemical nature. Macromolecules of dietary fibers do not dissolve in water as easily as molecules with a lower molecular weight, and high temperatures are required to dissolve some of them (highly methoxylated pectin, locust bean gum, gellan gum). The solubility of polysaccharides is determined by several of their structural characteristics: the branching of molecules, the presence of ionized groups, the type of bonds between monosaccharide units, and the heterogeneity of the structure. The results of the comparative analysis of the main physicochemical indicators of dietary fibers are given in the table 3.

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[12] Dixit, V., Joseph Kamal, S. W., Chole, P. B., Dayal, D., Chaubey, K. K., Pal, A. K., Xavier, J., Manjunath, B. T., & Bachheti, R. K. Functional Foods: Exploring the Health Benefits of Bioactive Compounds from Plant and Animal Sources. Journal of Food Quality, 2023 (1), 5546753. https://doi.org/10.1155/2023/5546753

[13] Culinary Nutrition: The Science and Practice of Healthy Cooking Jacqueline B. Marcus and Associates, Food and Nutrition Consulting, Highland Park, Illinois USA Elsevier Inc. 2014. 468 p. https://doi.org/10.1016/C2010-0-68663-9

[14] 12. 13. Saha D., Bhattacharya S. Hydrocolloids as thickening and gelling agents in food: a critical review. Journal of Food Science and Technology. 2010. 47(6), 587–597.

Table 3

Main physicochemical properties of dietary fiber

Name	Solubility	Stability	Viscosity	Emulsifying ability
Modified cellulose	+++	++	+	++
Pectin	+++	++	+	++
Inulin	++			
Biochemical gums	+++	++	++	++
Tree gums	+++	++	+	++
Algae gums	+++	+++	+	++
Tuber gums	+++	++	+	++

5. Application of dietary fibers on an industrial scale

Dietary fibers that have the status of food additives are classified into the appropriate groups of substances depending on their technological properties: thickeners (increase the viscosity of the product); gelling agents (give the food product the properties of a gel); stabilizers (due to an increase in the viscosity of food products, they stabilize dispersed systems, in particular suspensions, emulsions and foams, and prevent their separation into the initial components, for example, precipitation of solid particles dispersed in a liquid medium); emulsifiers (surface-active substances that, when adsorbed from a liquid on the surface of the phase separation, in particular liquid, solid or gas, significantly reduce the surface tension of water, which contributes to the formation and stabilization of emulsions); foaming agents (contribute to the uniform diffusion of the gas phase into liquid and solid food products). Recently, consumers have been giving preference to drinks made from natural plant raw materials. Fruit and berry and grain raw materials determine the nutritional and physiological value of the finished drink. At the same time, the components of plant raw materials, when converted into a drink, form a complex polydisperse system consisting of particles whose sizes vary in a wide range: large particles with a size of more than 0.1 microns; colloidal particles with a size of less than 0.1 microns; molecular particles with a size of less than 0.001 microns. Colloidal and molecular particles form a colloidal dispersed system, the physicochemical equilibrium of which ultimately determines important indicators of the quality of the finished drink − transparency, color, taste and aroma. Adding dietary fiber to drinks increases their viscosity and stability, and soluble fibers are most often used, since they disperse better in water than insoluble ones. The role of hydrocolloids is to ensure the stability of dispersions (suspensions, emulsions, foams) in the beverage production process and during their storage.

Carboxymethylcellulose (CMC) is often used in the food industry due to its special properties, such as the absence of odor and taste, zero calorie content, the formation of a clear solution without turbidity, the ability to prevent gravitational sedimentation of suspended particles, etc. Microcrystalline cellulose, or cellulose gel, and CMC are used in beverages as suspending additives, thickeners and stabilizers. They are usually considered natural and can be used as a source of fiber. They are stable at pH 3, which allows them to be used in the technology of acidic fruit drinks. Adding 0.4 to 0.5% CMC or xanthan gum to unclarified apple juice ensures its stable turbidity during a long storage period. At the same time, due to the lower molecular weight of CMC, the juice with its addition has a lower viscosity than the same juice with xanthan gum. In the process of producing soft drinks from fruit and berry raw materials, under the action of enzymes and as a result of mechanical processing, hydrolysis of fruit pulp substances occurs with the release, in particular, of positively charged protein molecules. The cell walls of the pulp contain pectin with free carboxyl groups, which give it a negative charge. The attraction of oppositely charged particles causes their flocculation and loss of solution stability. Due to its anionic nature, CMC has the ability to prevent protein precipitation and stabilize beverages when approaching the isoelectric point of proteins. In beverages with the addition of CMC, a decrease in viscosity is observed during acidification and heat treatment, but the viscosity practically does not change during storage. Such beverages can retain their properties for a long time, even up to one year. Many beverages are acidified to enhance taste and aroma, as well as to increase resistance to microbiological spoilage. For fruit drinks and their concentrates, CMC with a high degree of substitution and medium molecular weight is better suited, since it is the most resistant to acidic environments. There are special types of CMC designed for products with a low pH value. Due to its anionic nature, cellulose gum plays a buffer role in drinks, increasing the pH of the solution. Its use makes it possible to adjust the taste and aroma profile of the drink. In particular, CMC effectively reduces the sour and salty flavors of tomato juice, with little effect on the intensity of its taste and aroma. Medium-viscosity cellulose gum has little effect on the sweetness of an orange-flavored drink, but significantly reduces its sour taste. CMC is used to give fruit-flavored drinks a full taste and juice-like properties, in light and diet drinks – to reduce the amount of sugar in their formulations. Cellulose esters (hydroxypropylcellulose, methylcellulose, hydroxypropylmethylcellulose) are used in the technology of foamy carbonated and fruit drinks to stabilize the foam[15] [16].

[15] Rahman M. S., Hasan M. S., Nitai A. S., Nam S., Karmakar A. K., Ahsan M. S., Shiddiky M. J. A., Ahmed M. B. Recent Developments of Carboxymethyl Cellulose. Polymers. 2021. 13(8), 1345.

[16] Барбаш В.А, Дейкун І.М. Хімія рослинних полімерів. Київ: Каравела, 2018. 440 с.

Pectins are widely used as stabilizers in colloidal dispersion systems (emulsions), antioxidant-enriched foods, acidified dairy drinks, and high-protein fruit drinks. One of the most important properties of pectins as functional ingredients is their ability to form complex compounds when interacting with heavy and radioactive metal ions. Pectins are completely safe − there are no requirements for their permissible daily dose. In beverage technology, pectin is used for stabilization and emulsification, in particular in the production of carbonated soft drinks and instant soft drink concentrates; it is also used in the production of sauces, canned goods, and confectionery. If the content of native pectin in fruit drinks is insufficient, highly methoxylated (HM) pectin is used to thicken them and restore the fullness of taste. Pectins with a high methoxyl content are good agents for regulating the viscosity of fruit drinks. Their advantage is that they are a natural component of many juices. In HM pectins, more than 50% of the acid groups are esterified with methyl alcohol. In foods with a dry matter content of less than 55%, such pectin acts as a thickener and does not form a gel. A diluted pectin solution mimics the viscosity of a 15% sugar solution. By adding only 0.1% of highly methoxylated pectin to a low-calorie drink, the same consistency can be obtained as in a drink with a sugar content of 10-15%, and the same taste perception of the drink as a 15% sugar solution. Pectin can perform an important function in dairy products with low pH (yogurt drinks, milk or fruit juice drinks, acidified whey drinks, acidified soy drinks), problems arise, since at a pH value of the drink below the isoelectric point of the proteins present in it, the proteins tend to precipitate. For this reason, casein is often replaced, in whole or in part, by whey proteins, which are less sensitive to low pH. In this case, pectins stabilize acidic juices, dairy or soy beverages by forming a complex with the protein – the negatively charged pectin molecules surround the positively charged protein molecules and prevent them from clumping. To stabilize an acidified dairy beverage with a milk solids content of 8.5%, approximately 0.3% HM pectin is added. At the same time, up to 90% of this pectin added to the acidified dairy beverage does not interact directly with the casein micelles. The adsorbed pectin forms a barrier to the interaction between casein particles and protects them from flocculation, mainly due to steric repulsion. In addition, pectins prevent syneresis of beverages and improve the creamy texture. Pectins exhibit adsorption properties for aromatic substances of essential oils, although to a lesser extent than gum arabic.

New opportunities for creating nutritionally balanced food products are opened by inulin. This is due to its property of dissolving in water, which makes it possible to introduce inulin as a source of dietary fiber into various beverages. Inulin and fructooligosaccharides are natural carbohydrates, soluble dietary fibers, which, however, do not belong to food additives and are completely safe (there are no requirements for the permissible daily dose).

Among their main properties as functional ingredients, it is worth noting an increase in calcium absorption, a decrease in the total level of triglycerides, and prebiotic effects. Both substances contain fewer calories than sugar or starch, so they can be used to prepare low-calorie beverages. In addition, fructooligosaccharides are ideal sugar substitutes. The solubility of these short-chain oligomers is higher than that of sucrose. They acquire characteristics similar to glucose syrup or sugar, and have a sweetness of 35 to 55% compared to sucrose. In an acidic environment and at high temperatures, inulin and oligofructose can undergo hydrolysis to form shorter fructose chains, which leads to a partial or complete loss of their dietary properties, and in some cases to an increase in the sweetness of the finished drink. At temperatures of 70 – 90 ^{o}C and pH 4.0 and above, the hydrolysis process proceeds slightly. Gum arabic is considered the best additive to liquid products among all soluble dietary fibers, since it has a high solubility in water (over 50%). Even at a concentration of 10%, the solution does not thicken by more than 0.002 Pa–s. Other natural gums do not dissolve by more than 5% due to their high viscosity. In addition, gum arabic is odorless, tasteless, and stable in acidic solutions. Gum arabic is a functional ingredient – a source of water-soluble fibers that have prebiotic properties, it reduces the glycemic index by reducing the rate of sugar resorption. In view of this, gum arabic is a promising additive for obtaining non-alcoholic beverages of a health-improving nature. In particular, a new functional product has been developed – juice enriched with grape anthocyanins, in which gum arabic acts as a stabilizer. Gum arabic has the ability to stabilize emulsions of the "oil in water" type without changing their consistency, which is important in the production of emulsions for beverages. Such aromatic emulsions (essential oils) are used in the production of some non-alcoholic and alcoholic beverages to give them taste, color and aroma[17]. The composition of such emulsions includes all the necessary components, which significantly simplifies the technology of beverages. At the same time, obtaining a stable emulsion system is relevant and promising. The use of gum arabic as an adsorbent for aromatic substances of essential oils has advantages over the use of pectins. The emulsifier ensures uniform distribution of aromatic substances throughout the volume of the beverage during its storage. In carbonated soft drinks, citrus flavor and aroma are one of the most popular in the world. Citrus-flavored beverages are obtained mainly on the basis of essential oils from fruit peels. Since they do not dissolve in water, such aromatic substances are added to beverages by converting the essential oil into an “oil-in-water” emulsion. A typical citrus oil emulsion for beverages contains 6-8% aromatic substances and 3-8% water. A beverage concentrate

[17] Padil V. V. T., Wacławek S., Černík, M., Varma R. S. Tree gum-based renewable materials: Sustainable applications in nanotechnology, biomedical and environmental fields. Biotechnology advances. 2018. 36(7), 1984–2016.

is obtained from the emulsion by adding sugar syrup and citric or other acid. In the future, to prepare a beverage with the appropriate taste, aroma, appearance, rheological properties and stability, the concentrate is diluted with carbonated water approximately five times. Gum arabic is used to produce dry natural flavorings based on essential oils, which have a wide range of applications in food production, in particular fermented and soft drinks. It is advisable to use it when obtaining soft drinks using aromatic emulsions in an amount of 1-2 g/hl of the drink, which provides its delicate and soft aroma. Gum arabic acts as a stabilizer for juices, cloudy drinks and drinks with the addition of fruit pulp. As a food additive, it is used to prevent sugar crystallization. Tragacanth is used in the production of soft drinks as a thickener and a substance that helps suspend suspended particles (pulp), giving it the appropriate consistency. It prevents possible stratification of the liquid by increasing the density of the drink. The acid resistance of the gum, which is superior to other food hydrocolloids, allows you to increase the shelf life of drinks and prevents the sedimentation of small fruit particles. Tragacanth is also used for the production of flavored drinks, in which it is able to increase the density of essential oil particles used as flavorings. The action of the emulsifier at a small dosage allowed for use can be enhanced by adding pectin. Gum arabic and tragacanth in a ratio of 1:4 are used to reduce the viscosity of the emulsion without reducing its stability, as a result of which the consistency becomes liquid, suitable for spreading. Gum arabic can also be used for and providing greater fluidity to xanthan gum systems. In dairy and soy beverages, such as flavored milk, these stabilizers help suspend chocolate particles, increase viscosity, and improve taste. In addition, stabilizers are used as aids in high-temperature short-time (HTST) or ultra-high-temperature (UHT) processing of beverages. Karai gum is used in functional beverage technology as a source of dietary fiber, particularly in combination with guar gum.

Guar gum is a natural food additive that is tasteless and odorless and contains approximately 80% fiber. Guar gum is used in the production of functional foods, as it helps reduce their calorie content and enrich them with dietary fiber. The gum provides a medium viscosity of beverages without excessive stickiness, improves taste properties and promotes uniform suspension of particles, such as finely ground herbs or insoluble nutrients. It stabilizes suspensions, which is important when obtaining juices and cloudy drinks. However, guar gum cannot be used to thicken acidified dairy drinks due to separation of the protein phase at high dosages of this additive. Locust bean gum is suitable for the production of health drinks, in particular low-calorie, fiber-enriched drinks intended for diabetics. The gum forms solutions that are stable over a wide pH range, making it a very popular and unique stabilizer and thickener in many beverages. It is soluble only in hot water, but this does not complicate the technological process, since many beverages require heat treatment. Locust bean gum is used in fruit juice-based beverages, as well as in milk-enriched beverages (with a small proportion of milk), to prevent the precipitation of casein micelles and ensure the appropriate consistency of the beverage. The gum improves the stability of beverages during storage by thickening them and increasing their resistance to phase separation. Locust bean gum is also used in milkshake formulations at concentrations of less than 0.1% to thicken and give the beverage better taste properties.

Alginic acid, due to its properties as a physiologically functional ingredient, has found wide application in the production of functional food products. In neutral beverages, alginic acid can increase the stability of the product and prevent the separation of various ingredients in the system. However, at low pH levels, alginic acid forms a gel or precipitates, so it cannot be used as a stabilizer in the technology of some beverages, such as fruit juices. In this case, propylene glycol alginate (PGA) is used − an esterified derivative of alginic acid. PGA is soluble in water, and its solution remains stable in an acidic environment up to pH 3-4, at lower pH values α–alginic acid is formed and precipitates. Tolerance to an acidic environment together with strong resistance to metal ions makes PGA a very valuable additive in the technology of some beverages, such as lactic acid beverages, fruit juice-based beverages, etc. For fruit juices, one of the common problems during storage is the reduction of their stability and delamination. Hydrophilic colloids are often used to solve this problem, but if they significantly increase the viscosity of the juice, then its taste properties are also changed. PHA is ideal for improving the stability of pulp juice without any side effects. The addition of 0.1% PHA can ensure the stability of the juice without compromising its taste, while other hydrocolloids such as xanthan gum, carrageenans, etc. can have such an adverse effect. PHA also stabilizes the essential oil composition of the juice due to its good emulsifying properties. Alginates are compatible with a variety of beverage components, including other thickeners, sugar, oils, pigments and preservatives. Mixtures of PHA and xanthan gum are used in fruit juice-based beverages. Carrageenans, which are often used as beverage stabilizers, consist of three different fractions – kappa, iota and lambda. They are very sensitive to changes in protein content and beverage composition. Carrageenans are often used in beverages with neutral pH. They naturally interact with milk proteins, forming a light gel-like structure that provides stability to suspensions containing suspended particles. They also give beverages the desired consistency. In fermented milk beverages, carrageenans are used to prevent syneresis and improve taste properties.

Uses of gums obtained by biochemical methods Xanthan gum is widely used in beverages due to the extraordinary ability of its viscous solutions (weak gels) to thin at high shear rates, the ability to release flavor from thickened systems, and the stability of its solutions over a wide pH range. Promising application of the gum for obtaining low-calorie beverages. Xanthan gum is very good at suspending solid particles due to its high viscosity at rest. Due to this property, it can be used to ensure that pieces of seeds, fruits or berries remain in suspension in drinks. Thus, to give a functional drink the necessary viscosity and ensure that chia seeds remain in suspension for a long time, it is advisable to use xanthan gum at a dosage of 3 g/l of a 10% sugar solution. Xanthan gum improves the taste of fruit, in particular citrus, drinks. In drinks containing aromatic emulsions, the addition of xanthan gum in an amount of up to 0.5% helps stabilize them and improve the taste and aroma. Gellan gum prevents drinks from separating during storage and adds freshness. The gum stabilizes drinks with a low pH value, close to 3.0. Gellan gum is compatible with many juices, since it does not have a high reactivity towards proteins. It is easily dispersed and hydrated, so it does not require special mixing equipment. The addition of pectins enhances the beneficial properties of gellan gum. Now, mixtures of highly acylated gellan gum and pectin are being produced, designed specifically for use in the production of juice-containing beverages. They are added to the juice before sterilization at an optimal dosage of 0.25-0.3%. Hydration occurs under the conditions of juice sterilization − when heated to 85 ℃ for 30 s. At an increased concentration, gellan gum can provide stability to cloudy beverages and at the same time not give them an acidic viscosity. At a fairly low dosage, approximately 0.1%, it ensures that pieces of seeds, fruits and berries remain in the drinks in a suspended state. Low-acetylated gellan gum is suitable for the production of whey-based beverages, since whey contains calcium ions, which contributes to the production of a clear, low-viscosity beverage. A promising direction for the use of hydrocolloids capable of forming very soft gels at low concentrations is the preparation of new types of gel-like beverages. In particular, to obtain such beverages using gellan gum, its concentration should be 0.05-0.1%. Adding other gums the structure of gel-like drinks can be changed. Therefore, in soft drink technologies, the use of soluble dietary fibers as functional and technological additives can have various purposes, in particular, increasing viscosity (thickening), stabilizing dispersions (suspensions, emulsions, foams). In the direction of expanding the product range, the use of hydrocolloids in the technology of dry drinks – quick-dissolving concentrates is of great importance. The hydrocolloids used for this purpose should have good solubility in water and rapid hydration, which ensures rapid recovery of the drink, as well as the ability to stabilize dispersions and low hygroscopicity. It is advisable to use highly methoxylated pectin, gum arabic (in particular, in the production of flavors and fruit powders), carboxymethylcellulose with an average molecular weight (hydrates faster than gums with a high molecular weight), xanthan gum[18].

From a technological point of view, beverages are the best model for obtaining functional products, the growth of production and consumption of which has become a stable trend in the world in recent years. To give beverages targeted therapeutic, preventive and health-improving properties, they are enriched with natural biologically active components of plant origin. In particular, dietary fibers can be used as functional ingredients for this purpose. When developing beverage recipes, the concept of the beverage is first determined and the ingredients are selected, then the recipe is tested in laboratory and production conditions, and methods of processing and bottling the beverage are selected, which are key to ensuring its proper quality and stable shelf life. Developing a beverage recipe is complex and requires taking into account many interrelated factors. The main component of beverages is water, the content of which in beverages is from 75 to 99%. It is an ideal medium for transferring flavorings and nutrients from raw materials to the beverage and dissolving the beverage components. The quality of the resulting drink largely depends on the quality of the water. To give drinks the necessary properties, appropriate ingredients are used in their recipes: to give a sweet taste – sugar (has a high energy value, so recently it has been increasingly replaced by sugar substitutes or sweeteners, the norms for the introduction of the latter are regulated); to give a sour taste, softening sweetness, preservative effect − acids; to give the appropriate color − natural or synthetic dyes (using mixtures of synthetic dyes, almost any shade is obtained); to give an aroma − natural, identical to natural or synthetic flavorings, bases, emulsions, compositions; to give the desired consistency in the recipes of some drinks, thickeners, emulsifiers and stabilizers are used. The balance between sweetness and tartness largely determines the overall taste and aroma profile of the drink, so the ratio of sugars and acids plays a major role in its recipe. Acids give drinks astringency and improve the overall taste perception. Taste trends are variable. Drinks with some flavors have been in stable demand for many years, while new sophisticated flavors are emerging, so in recent years, drinks with exquisite combinations of fruit flavors have remained popular. To give drinks a functional orientation, vitamins, trace elements, dietary fiber, among others, are used. An important factor in the preparation of drinks with the addition of vitamins and minerals is their stability and solubility. It is necessary to take into account the effect of vitamins on the taste properties of the drink during its storage. At the same time, enrichment with minerals can cause solubility problems, in particular, some calcium salts are insoluble, and in some cases calcium can affect the

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[18] Луговська О. А. Дослідження ступеня гідролізу інуліну та олігофруктози в напоях. Вчені записки ТНУ імені В.І. Вернадського. Серія : технічні науки. 2019. 30 (69), 2, № 2, 162–166.

solubility of proteins present in the drink. Hydrocolloid stabilizers, while enriching beverages with soluble dietary fibers, perform various technological functions, including stabilizing the beverage and providing specific properties of the finished product, in particular thick or liquid, creamy or light consistency through their interaction with other components present in the beverage. The choice of a particular hydrocolloid for use in a particular beverage depends on the characteristics of the additive. There is a fine line between excessive and insufficient stabilization of beverages. On the one hand, the system can become viscous or gel-like in case of excessive stabilization, on the other hand, proteins or other substances can precipitate if the beverage is not sufficiently stabilized.

Dietary fibers usually reduce the taste and aroma properties of ingredients, so they should be added before adding flavoring components. Despite the numerous positive effects achieved in beverage technology due to the use of dietary fibers, not all of them function equally at different pH values and electrolyte concentrations, heat treatment, have different stability during storage, etc. In this regard, the task facing manufacturers is to choose the optimal hydrocolloid taking into account the purpose of its use. When choosing dietary fibers, it is necessary to take into account their following important properties: solubility, ability to increase viscosity, gelation, stabilization of emulsions, heat resistance, stability of solutions in an acidic environment, ability to suspend suspended particles, ease of use, etc. The effectiveness of using dietary fibers to give beverages a functional direction and improve the quality characteristics of beverages is determined by the characteristics of their chemical structure, physicochemical and technological properties. In addition, the effectiveness of hydrocolloids is determined by the composition of the drink. It is also necessary to take into account their ability to form associates with other polymer components, for example, with proteins, which can significantly increase the viscosity of the system. Most often, the dosage of dietary fibers does not exceed 0.1%. The demand for hydrocolloids depends on four key factors: ease of use, quality, functional properties, cost. Prices for soluble dietary fibers vary greatly. Pure gellan gum is one of the most expensive hydrocolloids, its price is approximately $ 40 per 1 kg. In contrast, guar gum, among the hydrocolloids studied, is at the other end of the scale (1-3 $ per 1 kg). Prices for hydrocolloids depend on the availability of raw materials, demand in other (non-food) industries, processing capabilities, logistical conditions, and therefore are subject to considerable fluctuations. When choosing soluble dietary fibers for the most effective solution of specific technological tasks in the technology of soft drinks, it is necessary to take into account: 1) the need to ensure appropriate rheological properties of the drink (or the formation of the appropriate texture of gel drinks) due to increased viscosity or gelation; 2) optimal dosage of the additive to ensure the achievement of the desired end result − the formation of proper viscosity or the formation of a gel of a certain strength; 3) method of application – individually or together with other hydrocolloids, as a result of which it is possible to achieve a synergistic effect[19] [20].

CONCLUSIONS

The data of the scientific literature of recent years on the technological aspects of the use of soluble dietary fibers in the production of soft drinks were analyzed.

The classification and structural features of soluble dietary fibers (modified celluloses, pectins, inulin, gums from tree bark, from tree seeds, from algae and obtained biochemically using microorganisms) were considered. A comparative analysis of the main physicochemical properties of soluble dietary fibers was carried out, namely: solubility in cold and hot water, stability of solutions to heat and pH changes, viscosity of solutions, ability to stabilize emulsions, conditions required for gelation, thermoreversibility of gels. The directions of application of soluble dietary fibers in the technology of soft drinks were considered. The objects for introducing dietary fibers and their dosage volumes in the production of soft drinks are proposed to solve specific technological tasks: giving drinks a functional direction (enrichment with dietary fibers, preparation of low-calorie drinks with a reduced sugar content), clouding of drinks, stabilization of emulsions, stabilization of foam, stabilization of consistency, reduction of flavors, in particular sour and salty. The factors that need to be taken into account when choosing soluble dietary fibers for effective solution of technological tasks in the technology of soft drinks are analyzed. Recommendations are proposed for the development of soft drinks with dietary fibers, in particular functional ones. The prospects for the use of dietary fibers in beverage technologies are associated with the growing awareness of their important functional properties and the role that they play in human nutrition.

SUMMARY

Dietary fiber (also known as dietary fiber, plant fiber) is a plant component. It resists hydrolysis by digestive enzymes. That is, dietary fiber is resistant to the process of digestion and adsorption. It is not broken down during digestion in the stomach and intestines. In terms of chemical composition, plant fiber is a heterogeneous group of substances that contains polysaccharides, lignin, cutin, agaroids, carrageenans and alginates. The

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[19] Catherine Atkinson The Vegan Dairy. 2020. NY: Anness Publishing. 240 p.

[20] Taherian, A. R., Fustier, P., Britten, M., Ramaswamy, H. S. Rheology and stability of beverage emulsions in the presence and absence of weighting agents: a review. Food Biophysics. 2008. 3, 279–286.

content of dietary fiber in food varies from 0% to 45-55%. Dietary fiber can be divided into the following main categories: soluble; insoluble.

Soluble fiber forms a gel-like mass in the stomach. It helps to reduce cholesterol and glucose levels in the blood, and also improves intestinal function. Foods rich in soluble fiber include apples, oats, peas, beans, and citrus fruits. Insoluble fiber, on the other hand, helps move food through the digestive system. It also improves bowel function. Insoluble fiber is usually found in the skins of fruits and vegetables, as well as in grains (wheat, barley, etc.). The benefits of dietary fiber for human health are hard to overestimate, and among the main benefits are:

– Maintaining the digestive system. Dietary fiber contributes to the normal functioning of the intestines, ensures regular bowel movements, and prevents diarrhea and constipation.

– Blood sugar control. Fiber slows down the absorption of sugar from food, which helps maintain stable blood glucose levels and reduce the risk of developing type 2 diabetes.

– Reducing the risk of obesity. Fiber helps to achieve a feeling of satiety and reduces appetite.

– Reducing the risk of cardiovascular disease. Plant fiber reduces the amount of harmful cholesterol in the blood, thereby reducing the risk of heart disease and hypertension.

– Prevention of certain types of cancer. Modern studies show that dietary fiber can reduce the risk of certain types of cancer, such as colon cancer.

– Maintaining overall health. Consuming foods rich in fiber helps provide an optimal environment for the growth and reproduction of beneficial bacteria in the intestines. This contributes to overall health and a stronger immune system.

Cereal products occupy an important place in the diet of the population, as they contain nutrients necessary for the normal functioning of the human body (macro- and microelements, vitamins, enzymes, dietary fiber, phospholipids and other biologically active substances). Currently, work is being carried out quite intensively to expand the range of new types of cereal products with increased nutritional value, namely, composite flour mixtures, bakery, pasta and confectionery products, food concentrates enriched with additives of both plant and animal origin. One of the groups of cereal products that have significantly changed people's habits and are widely used by the population of many countries as ready-made breakfasts is extruded cereal breakfasts, which are characterized by low moisture content, long shelf life, light weight and loose structure, ease of use, convenient individual packaging and transportability. Therefore, the development and commercial evaluation of new types of extruded grain products with increased nutritional value, enriched with various types of additives, is relevant.

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